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DOWNY AND POWDERY MILDEWS OF THE GRAPE AND THEIR CONTROL

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F. E. GLADWIN

INTRODUCTION

These two diseases of the grape have long been known in New York, but it is only in a season favorable for the rapid spread of one or the other that the average grower becomes alarmed and is spurred into action. When he has arrived at this stage, however, it is usually too late to combat either successfully. If perchance weather conditions are such as to check further spread in any season, the grower is inclined to assume that nature will probably favor him another year. Unfortunately, as with many other ills of plants, it is impossible to predict the probable degree of occurrence of either of these diseases in advance.

In 1928, the Legislature passed a law providing for the grading, classifying, and packing of grapes and placed the establishment of standards and administration of the law in the hands of the Commissioner of Agriculture and Markets. This act became operative in marketing the 1928 grape crop. The present grades recognize both downy and powdery mildew as objectionable in all classes except the "Ungraded." The latter may include practically everything that resembles a grape. Fortunately or unfortunately, both forms of mildews became of serious import in 1928, hence the call for control measures for these diseases was greater in that season than the total calls of the entire 19 preceding seasons. The irregularity with which spraying had been done served to confound the grower as to the proper measures to take. Very probably, too, some were of the opinion that newer methods of control had been found that would simplify the task. It will be seen later that none of the newer measures of control surpass the older.

DOWNY MILDEW

In New York, this disease (Fig. 1) of the grape seems to be limited to a large extent to the Finger Lakes region, and more especially to the Keuka Lake portion of that region. It is of rare occurrence in commercial plantings of western New York, as only susceptible var-

ieties have occasionally shown the trouble during the past 20 years. It is generally agreed that the fungus is carried thru the winter on the fallen leaves, the oospores being set free by the rotting of the leaves and germination occurring in the soil. Temperatures ranging from 77° to 83° F are best for the growth of the fungus. Shaded, moist locations are favorable for its development, but on the other hand, long periods of dry weather serve only to check it somewhat.

FIG. 1.—DOWNY MILDEW ON GRAPE LEAF.
(Photograph by courtesy of Department of Plant Pathology, College of Agriculture, Ithaca, N. Y.)

The upper surfaces of the leaves show the first signs of the disease with small, greenish yellow, indefinite spots. These spots gradually become brown, dry, and brittle. On less susceptible varieties there

occurs only a slight change in color. On the lower surface of the leaf the spots at first have the same characters, but they are very soon covered with a downy, white growth.

The first indication of the disease on the fruit is a hardening of the berry, together with a change from its normal color to a grayish, blue lead color. In later stages the berry turns a livid brown or red and finally shrivels into a mummy. Badly diseased fruits "shell" easily.

CONTROL

This Station for several years tested various materials for the control of downy mildew in its vineyards at Urbana, N. Y., a section in which this disease is quite common ordinarily. Not alone were different materials tested, but an effort was made to determine at what stage of development of the fruit most effective applications should be made.

As a result of this work it is concluded that a 4–4–50 bordeaux mixture is just as effective as those carrying a larger amount of copper, and that the disease can be effectually controlled by it. Formerly it was believed that more copper was required. Bordeaux and copper-lime dusts of different brands were in no way comparable with the 4–4–50 bordeaux. The failure of these latter to control was probably due to their lack of ahhesiveness, the lightest rains serving to wash the materials from the berry surfaces to their lowest areas, while the dust deposited on the base of the cluster was carried down to the apex where it accumulated in quite large chunks. These chunks on drying broke away and fell to the ground. It seemed with the commercial bordeaux dusts that much of the lime had carbonated previous to the applications. The copper-lime dusts were more adherent. Owing to the unfavorable outcome of some earlier work with sulfur-lime dusts for the control of powdery mildew, the latter was not used in the Urbana vineyards.

It was concluded from these studies that the most important application for the control of downy mildew in the Keuka Lake section is that made just previous to blooming. Some investigators note that the attack from this mildew may come at any time from flowering to maturation. The second spray should be applied just as soon as the blossoms are set. In the Keuka section a third application is often required, while in seasons very favorable for the spread of mildew a fourth application is necessary.

The third application should be made just before the berries touch in the cluster, and the fourth should follow about two weeks later. With the third and fourth applications powdered arsenate of lead may be added at the rate of 3 pounds to 100 gallons of bordeaux mixture if leaf-chewing insects are present. The addition of 3 pounds of resin fish oil soap to 100 gallons of the mixture in the third application increases materially the spread of the spray over the berries, which in turn makes for greater adhesiveness. In the spray program followed at the Station Vineyard Laboratory at Fredonia in 1928 menhaden fish oil was substituted for resin fish oil soap with good results, but it was used at only three-fourths of the amount recommended by the manufacturers. The use of any spreader in the fourth or subsequent applications is not advisable because of the residues likely to result.

The best results in spraying for downy mildew have been obtained thru the use of hand-directed spray nozzles rather than from fixed nozzles as is the common practice in the control of powdery mildew in western New York. The pressure derived from wheel-driven pumps supplied two leads of hose with two nozzles each. Thus two halves of two adjacent rows are sprayed by going once thru the row.

Since the spores of the fungus winter over on the fallen leaves, it is believed that their turning down by plowing in early spring lessens the sources of infection. However, thus far, this has not been closely checked.

It is practically impossible to check the spread of downy mildew once it has worked into the interior of the berries, peduncles, or pedicels. Clusters and berries showing no early infection can be protected by late applications, but it may not be economical if the early infection is general.

POWDERY MILDEW

In the French vineyards powdery mildew (Figs. 2 and 3) is apt to be very serious at blossoming time, but in western New York this disease rarely appears before early and middle July. In some seasons it is even late July or early August before it assumes dangerous proportions. Ordinarily, powdery mildew is considered a dry weather fungus, yet during the past 20 years the worst infections have been in seasons of much rainfall or humid weather. The first spots of mildew appear on the green parts of the vine, and in a short time leaves

can be found that are overrun with the fungus. Berries then begin to show the dwarfing effect of the disease, but the parts on which the spread is most rapid are the peduncles and pedicels. If the disease is not controlled, these parts are withered and brown by harvest time,

FIG. 2.—POWDERY MILDEW ON GRAPE LEAF.
(Photograph by courtesy of Department of Plant Pathology, College of Agriculture, Ithaca, N. Y.)

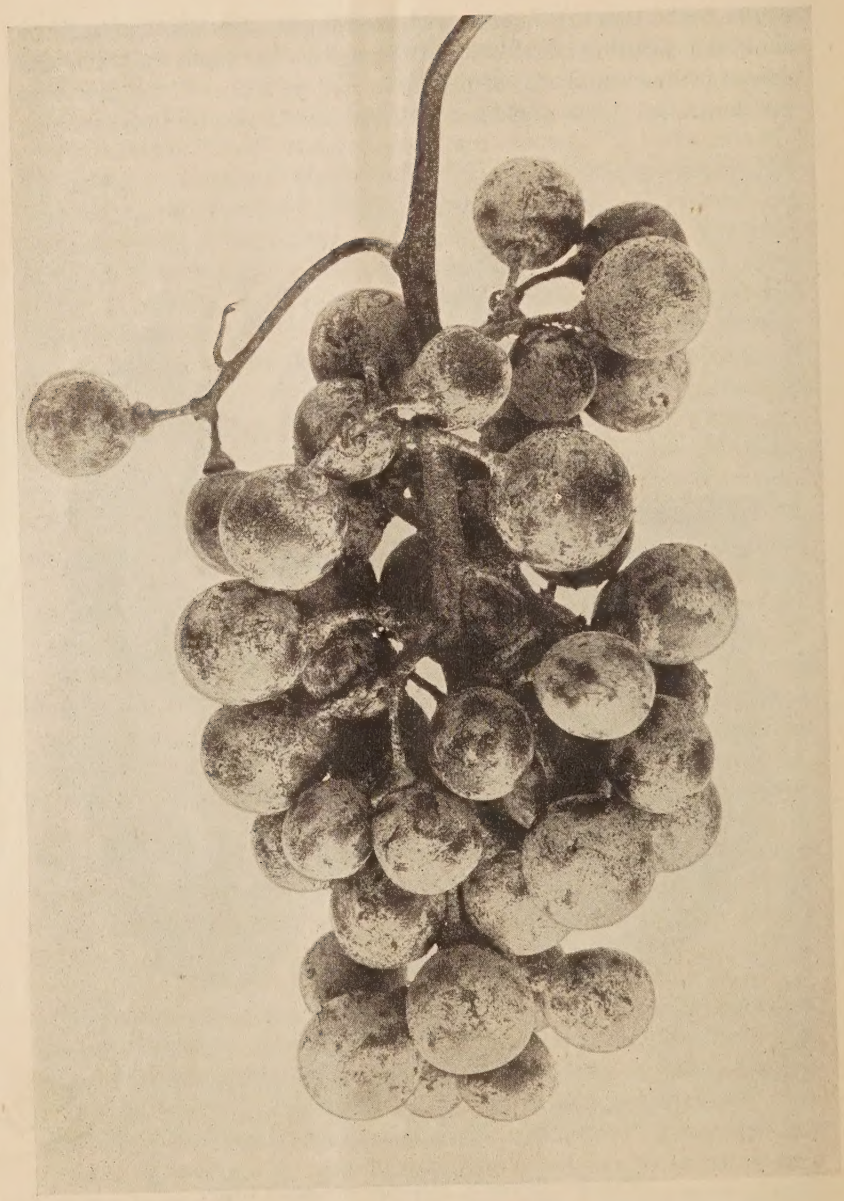

FIG. 3.— POWDERY MILDEW ON GRAPE CLUSTER.

(Photograph by courtesy of Department of Plant Pathology, College of Agriculture, Ithaca, N. Y.)

while the berries of many clusters are covered with a grayish-white fuzz. With severe infections the leaves appear covered with a thin whitish film. The drying of the pedicels favors a shattering or "shelling" of the berries, while the brittleness of the peduncles frequently means many clusters whipped from the vines by winds as the maturity of fruit is reached. Until the passing of the grape grading law powdery mildew was not considered a serious trouble by the average grower. Unfortunately, he rarely saw his basket grapes after they had been subjected to long distance shipment by rail or truck. Trial shipment of basket grapes affected with this mildew made by the Vineyard Laboratory to mid-western territory revealed the fact that the disease caused an immense amount of "shelling" en route, which in turn, resulted in an unsightly and unsatisfactory package at destination. Whether the causal fungus passes the winter on the canes, fallen leaves, or in the soil, the methods of control are limited to summer sprayings.

CONTROL

Since the margin of profit on grapes is not very great, all of the above factors enter into consideration in planning a method of mildew control that will be accepted and put into practice by grape growers generally. That mildew is relatively easy to control is attested by the fact that the disease is usually dismissed by compilers of information with the statement that treatments for black rot and downy mildew will serve to hold this disease in check. Since the grower of grapes in Chautauqua County can use a spray with profit in fighting the root-worm, some of the first efforts in mildew control were to combine a fungicide with the poison.

In 1911, the Vineyard Laboratory, in cooperation with the Botany Division of the Station, began a series of treatments with a block of Lindley grapes. This variety was selected because it is, like all of Rogers' hybrids, particularly susceptible to powdery mildew. The first tests involved a comparison of dormant with summer applications. On April 27, 1911, two rows of 20 vines each were sprayed with atomic sulfur at the rate of 4 pounds to 100 gallons of water, several adjacent rows being reserved for summer applications and controls. Summer treatments of atomic sulfur at the above rate combined with arsenate of lead were given on July 1, 21, and 31. Other rows of the same vineyard were dusted with a 90–10 sulfur-lime mixture on July 14 and 31. So far as control of mildew is concerned the summer

applications of dust and atomic sulfur effectually controlled the disease, while the dormant application of the latter had no effect whatsoever. The summer applications of atomic sulfur, however, resulted in some injury to leaf, shoot, and fruit. Sulfur-lime dust was again applied to the Lindley vines in 1912 and 1913 with excellent results. The control rows showed but 2 per cent of the clusters free of mildew in 1913 as compared with 77 per cent free for the sulfur-lime dusted rows. Applications of sulfur dust in 1912 to Delaware and Concord vines failed to show any marked differences over the controls, owing largely to weather conditions unfavorable for the spread of the disease. No injury to the vines or fruit was noted.

In 1914 the same lot of Lindley was dusted three times. Only general observations were made that year, but it was plainly evident that the applications of dust were as effective as in 1913. The first indication of injury was noted at this time, a few leaves showing burned areas. In this season a variety vineyard of 125 varieties was sulfured with a traction duster. Within four weeks after the first application it was evident that considerable injury had been done. At the previous applications on the Lindley vines a few Concord vines mixed in the planting had also received the sulfur-lime dust with no apparent injury.

A number of Concord vineyards in widely scattered locations were chosen for treatment in 1914. Three grades of sulfur were utilized, *viz.*, flowers, ordinary brimstone, and an exceedingly finely ground flour sulfur. Approximately half acre blocks in each of 47 vineyards were dusted. The first application was completed on all by July 31. At the time selected for the second treatment it was seen that injury had resulted from the first treatment, hence applications were discontinued. The injury became worse as the season advanced so that at harvest time many of these vineyards were practically defoliated, while the fruit development had been checked and the fruit and canes subsequently failed to mature. Only 1 grower of the 30 who reported on the extent of injury noted no ill effects.

Work in subsequent years with sulfur-lime dusts of varying compositions showed that Concord was susceptible to injury at the 90–10 ratio in most seasons, while other combinations utilizing lesser amounts of sulfur were ineffective for the control of mildew. However, the 90–10 sulfur-lime dust is very effective and causes but little injury even in seasons most favorable for injury when applied to such Rogers' hybrids as Lindley, Agawam, Goethe, Salem, and Requa.

In fact better control is obtained with these varieties with the dust than from bordeaux mixture. Injury from sulfur-lime dust seems to be correlated with high summer temperatures and scant rainfall. The amount of injury seemed to be independent of the method of application. The early applications were made with a knapsack bellows duster, while, in later years, a French traction machine was used. In 1918, tests with sulfur-lime dusts were discontinued.

Bordeaux mixture with arsenate of lead has long been the accepted spray combination in western New York vineyards and the effectiveness of the fungicide has rarely been questioned. Some growers feel, however, that the use of commercial materials containing copper that will readily make a suspension in water would simplify grape spraying. Others would like to eliminate all applications involving the use of water, employing in their place copper-lime and bordeaux dusts. In consequence some of these have been tested under commercial conditions, and the conclusion has been reached that, all things considered, the homemade 4–4–50 bordeaux mixture is still the surest and safest fungicide for the control of powdery mildew on Concord grapes in western New York. Tests in 1914 show that one application of a 4–4–50 bordeaux made on July 2 gave 67 per cent of the clusters entirely free from mildew, while but 15 per cent of the clusters from adjacent unsprayed vines were free of the trouble. Over 1,000 clusters were examined in each lot. Further studies made in 1928 show the following results:

Treatment	Percentage of clusters badly infected with mildew on peduncles and pedicels	Percentage of berries showing mildew	Percentage of berries that "shelled" because of mildew on pedicels
Vines sprayed July 7 and 20	2.8	0.9	0.08
Vines unsprayed	100.0	7.5	2.10

These counts involve random samples of approximately 100 pounds of fruit for each lot and were taken at the time of commercial harvest. About 50 per cent of the clusters from the sprayed vines showed a trace of powdery mildew somewhere on the cluster. Even the smallest area on a single pedicel was recorded. The small infection spots in no way affected the appearance nor the grading of the fruit. In fact all of it was classed by the inspectors as No. I Juice Grapes and the

comment on the greenness of the peduncles and pedicels as compared with unsprayed grapes was quite general. The 100 per cent infection of the unsprayed grapes has not been equalled within the past 20 years. This fact only serves to emphasize the severity of the disease in 1928. The clusters recorded as with a trace could no doubt have been largely eliminated had the second spray been carried thru to completion on schedule.

The results obtained with two applications of a 4–4–50 bordeaux mixture in 1928 for powdery mildew control further emphasize the value of this fungicide as a grape spray, not alone because of its effectiveness but also from a cost standpoint. At retail prices for copper sulfate, hydrated lime, and fish oil soap, the cost of materials for a single application of bordeaux mixture and spreader was $2.35 per acre. If the insecticide was added the cost was $3.25.

The presence of a slight amount of mildew on occasional berries before the first application was made on July 7 suggests that the treatment should be given a trifle earlier. This treatment is usually correlated with that for the first grape root-worm spray. However, both can probably be set forward a few days which would bring them at about the stage at which the berries have just begun to touch in the cluster. In the Chautauqua district this is usually the first week in July and in the Niagara district approximately a week or ten days later, while in the Keuka section it is a week or ten days earlier. The second application should follow in about two weeks. If weather conditions are unfavorable for vine growth, the interval between the applications should be lengthened somewhat.

The results for 1928 at Fredonia have shown that two sprays will control the severest infections, but in other districts, such as the Niagara district, a third application in two weeks may be required. Resin fish oil soap at the rate of 3 pounds to 100 gallons of mixture or menhaden fish oil, 1½ pints, pays for the cost several times over in a more uniform spread, and hence, the use of less of the mixture. However, either spreader should only be used in the first two sprays.

While dense foliage, closely adjacent woodlots, and the presence of tall weeds in the vineyard present conditions that are favorable for the spread of powdery mildew, their elimination will only lessen the trouble in a slight degree. Recourse must be had to thoro and timely spraying. Badly mildewed clusters which were fully exposed to the sun and which offered a free exposure to air currents have been noted innumerable times. It is thought that since these are,

as a rule, close to the upper trellis wire, that condensation of atmospheric moisture on the wire, which, in turn, trickles down to the clusters explains this anomaly. It is known that powdery mildew thrives best in locations with poor air drainage. Recent French investigations have brought out the fact that copper deposited on the berries, peduncles, and pedicels acts over a long period by reason of small portions becoming soluble with each light rain, or heavy dew, which in turn flows and covers some of the increasing areas of peduncle, pedicel, and berry tissues. This would seem to account for the prolonged effectiveness of a single application of bordeaux mixture. Further, the same investigators point out that a minimum amount of copper is sufficient to kill the spores of powdery mildew. In fact they state that, "the spores of this disease are among the easiest to destroy of all of the common plant diseases." These findings are in conformity with the opinions of American plant pathologists, namely, that "the disease is easily controlled."

BLACK ROT

The control of downy mildew in the Finger Lakes Section fits in almost perfectly with the usual recommendations for the control of black rot in that region, to the end that probably the only deviation might be additional later sprays than are recommended for the mildew.

MAKING BORDEAUX MIXTURE

Despite a too prevalent idea that the home making of bordeaux mixture is a disagreeable and complicated process, it can be shown that neither is true, except that all spraying and dusting are not the most pleasant tasks. The methods of preparing stock solutions and suspensions of copper and lime are by no means new, having persisted for many years. The plan used at the Vineyard Laboratory is the old one with possibly a few changes. Two 50-gallon barrels are necessary. Into each is run 40 gallons of water. Into one is dumped 40 pounds of fresh, hydrated lime. This should not have been carried over by the dealer from the previous year. In the other barrel is suspended just below the surface of the water in an old sack 40 pounds of copper sulfate crystals. If the crystals have been pulverized the copper will go into solution much quicker. However, 12 or 15 hours will suffice to bring the crystals into solution. To make the 4–4–50 mixture, the spray barrel or tank is filled to three fourths

capacity, when 4 gallons of the copper water is added, after thoroly stirring. Then the lime and water are well mixed, and 4 gallons are added to the tank as the whole is thoroly agitated, either by starting the engine or by a hand paddle. If a poison is to be used, it is now added after it has been worked into a thin, smooth paste in a little water. Lastly the spreader is put in the mixture. If resin fish oil soap is used, it should also be worked into a little water before putting in the tank. Menhaden fish oil should be diluted with water before it is brought into contact with the other materials. Since 1 gallon of the copper water and 1 gallon of the lime water each carries, respectively, a pound of copper and lime, it is only necessary to add as many gallons of each as the capacity of the spray tank requires. A 100-gallon tank thus requires 8 gallons of each, a tank of 150 gallons capacity 12 gallons of each, and so on. After several tanks have been emptied it will be found that considerable foaming has resulted if the resin fish oil soap has been used. In this event it is well to omit the soap in a few subsequent fillings.

CONCLUSIONS

Available data and the experience of practical growers indicate that homemade bordeaux mixture, well made and timely applied, is still the most effective spray material for use in the control of downy and powdery mildews, and further, that it is also the most economical. The evidence seems to justify the conclusion that three applications of bordeaux mixture are sufficient to control downy mildew in the Finger Lakes region in most seasons, while two treatments will control the severest infections of powdery mildew in southwestern New York with probably one additional application required in the Niagara district.

A spreader, such as resin fish oil soap or menhaden fish oil, is deemed desirable for the early season applications, but spreaders should be omitted in the later treatments because of the likelihood of spray residues.

It is believed that with vines of very heavy foliage the spray can best be applied by hand-directed nozzles, but in the Chautauqua region sprayers equipped with three fixed nozzles on each side of the sprayer are wholly effective in the average season. The nozzles can be raised or lowered to meet the needs of the various training methods.